# Math with Lenses – Worksheet

1. A glowing object that is 2.5 cm tall is placed 20.0 cm in front of a converging lens. If the focal length of the lens is 7.5 cm, determine:

   a) The distance between the image and the lens.

   $h_o = 2.5cm$
   $d_o = 20.0cm$
   $f = 7.5cm$
   $d_i = ?$

   $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

   $\frac{1}{f} - \frac{1}{d_o} = \frac{1}{d_i}$

   $\frac{1}{7.5cm} - \frac{1}{20.0cm} = \frac{1}{d_i}$

   $\left(\frac{1}{12cm}\right)^{-1} = \left(\frac{1}{d_i}\right)^{-1}$

   $12cm \approx d_i$

   b) The size of the image.

   $h_i = ?$

   $\frac{h_i}{h_o} = \frac{-d_i}{d_o}$

   $h_i = \frac{-d_i h_o}{d_o}$

   $h_i = \frac{-12cm(2.5cm)}{20.0cm}$

   $h_i = -1.5cm$

   c) Whether the image is real or virtual. How do you know?

   Real ⇒ di is positive and hi is negative

2. An object is placed 9.00 cm from a diverging lens. The object is 4.00 cm tall and the focal length of the lens is 5.00 cm. Determine:

   a) The distance between the image and the lens.

   $d_o = 9.00cm$
   $h_o = 4.00cm$
   $f = -5.00cm$
   $d_i = ?$

   $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

   $\frac{1}{f} - \frac{1}{d_o} = \frac{1}{d_i}$

   $\frac{1}{-5.00cm} - \frac{1}{9.00cm} = \frac{1}{d_i}$

   $\left(\frac{-14}{45.0cm}\right)^{-1} = \left(\frac{1}{d_i}\right)^{-1}$

   $\frac{-45.0cm}{14} = d_i$

   ~~$-0.311cm \approx d_i$~~

   $d_i \approx -3.21cm$

   b) The size of the image.

   $h_i = ?$

   $\frac{h_i}{h_o} = \frac{-d_i}{d_o}$

   $h_i = \frac{-d_i h_o}{d_o}$

   $h_i = \frac{-(-3.21cm)(4.00cm)}{9.00cm}$ (~~$-0.311cm$~~ replaced by $-3.21cm$)

   ~~$h_i \approx 0.138cm$~~

   $h_i \approx 1.43cm$

   c) Whether the image is real or virtual. How do you know?

   Virtual ⇒ Diverging lens, di is negative, hi is positive

3. A 6.00 cm tall candle is placed 9.00 cm from a converging lens with a focal length of 8.00 cm. Determine the location of the image and the magnification. Is the image upright or inverted?

$h_o = 6.00cm$
$d_o = 9.00cm$
$f = 8.00cm$
$d_i = ?$
$M = ?$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} - \frac{1}{d_o} = \frac{1}{d_i}$

$\frac{1}{8.00cm} - \frac{1}{9.00cm} = \frac{1}{d_i}$

$\left(\frac{1}{72.0cm}\right)^{-1} = \left(\frac{1}{d_i}\right)^{-1}$

$d_i = 72.0cm$

$M = \frac{-d_i}{d_o}$

$M = \frac{-72.0cm}{9.00cm}$

$M = -8.00$

Inverted

(M is negative)

4. A diverging lens has a focal length of 4.5 cm. An object 5.0 cm tall is placed 4.5 cm from the lens. Find the size and location of the image.

$f = -4.5cm$
$h_o = 5.0cm$
$d_o = 4.5cm$
$d_i = ?$
$h_i = ?$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} - \frac{1}{d_o} = \frac{1}{d_i}$

$\frac{1}{-4.5cm} - \frac{1}{4.5cm} = \frac{1}{d_i}$

$\left(\frac{-4}{9cm}\right)^{-1} = \left(\frac{1}{d_i}\right)^{-1}$

$\frac{-9.0cm}{4} = d_i$

$-2.3cm \approx d_i$

$\frac{-d_i}{d_o} = \frac{h_i}{h_o}$

$\frac{-d_i h_o}{d_o} = h_i$

$\frac{-(-2.3cm)(5.0cm)}{4.5cm} = h_i$

$2.6cm \approx h_i$

($2.5cm$ if $d_i = -2.25cm$)

5. The magnification of an image is -2.35x. If the height of the object is 6.35 cm and is 8.50 cm from the lens, what is the focal length? → converging lens!

$M = -2.35x$
$h_o = 6.35cm$
$d_o = 8.50cm$
$f = ?$
$d_i = ?$

$M = \frac{-d_i}{d_o}$

$-M d_o = d_i$

$-(2.35)(8.50cm) = d_i$

$20.0cm \approx d_i$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

~~$\frac{1}{f} = \frac{1}{20.0cm} + \frac{1}{f}$~~

$\frac{1}{f} = \frac{1}{8.50cm} + \frac{1}{20.0cm}$

$\left(\frac{1}{f}\right)^{-1} = \left(\frac{57}{340cm}\right)^{-1}$

$f \approx 5.96cm$

6. A 4.0 cm tall object is placed 2.0 cm from a converging lens. If the image is real and is 8.00 cm tall, what is the focal length of the lens?

$h_o = 4.0cm$
$d_o = 2.0cm$
$h_i = -8.00cm$
$f = ?$
$d_i = ?$

$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$

$\frac{-h_i d_o}{h_o} = d_i$

$\frac{-(-8.00cm)(2.0cm)}{4.0cm} = d_i$

$d_i \approx 4.0cm$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

$\frac{1}{f} = \frac{1}{2.0cm} + \frac{1}{4.0cm}$

$\left(\frac{1}{f}\right)^{-1} = \left(\frac{3}{4.0cm}\right)^{-1}$

$f \approx 1.3cm$